Feb. 22, 1949. A. H. EPPLER 2,462,480

POLISHING METHOD AND APPARATUS

Filed Jan. 8, 1944

2 Sheets-Sheet 1

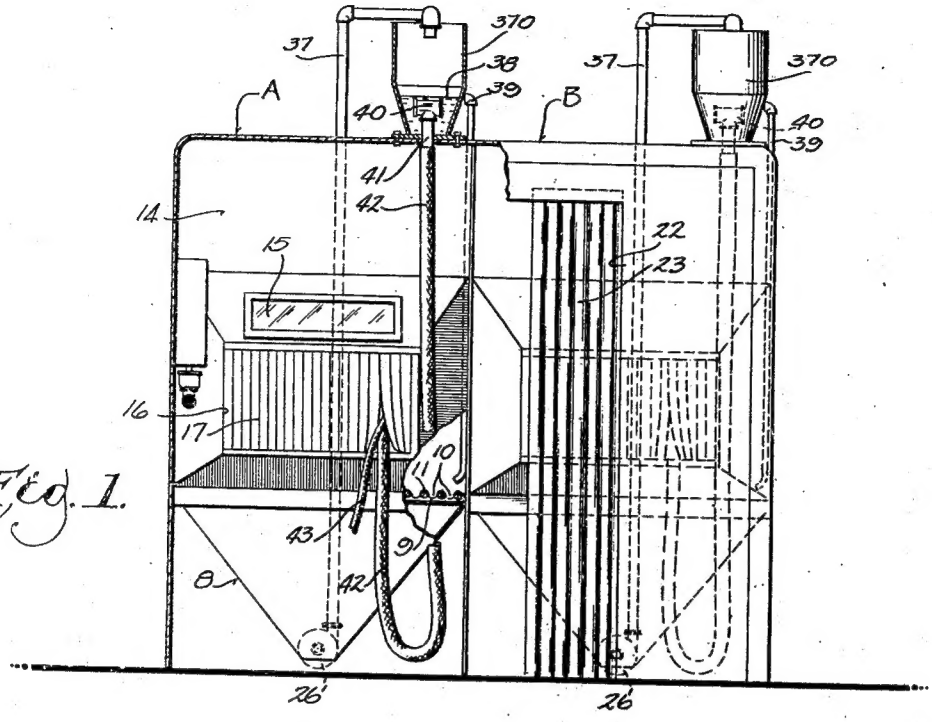

Fig. 1.

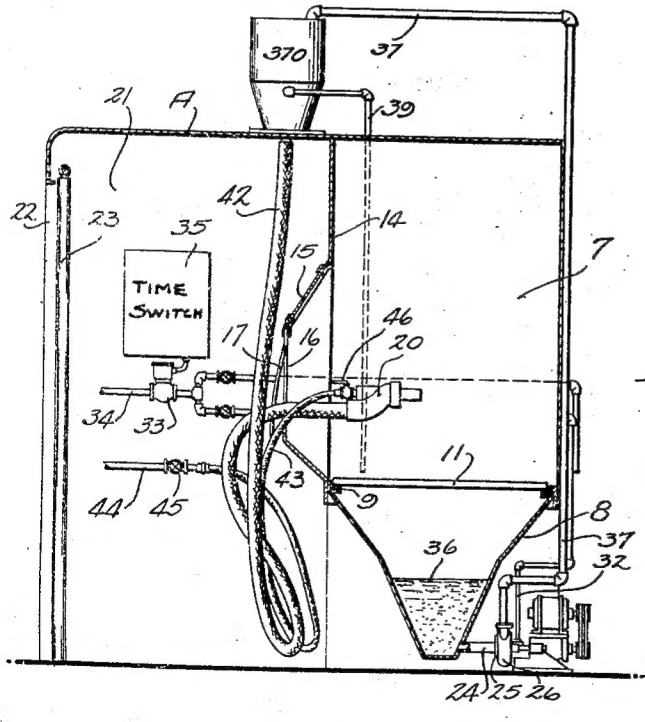

Fig. 2.

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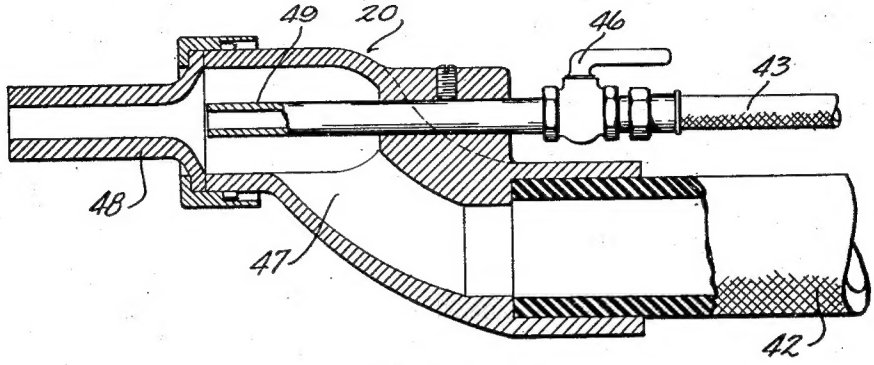

Fig. 3.

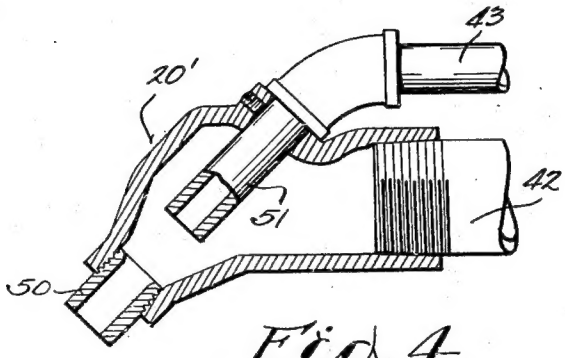

Fig. 4.

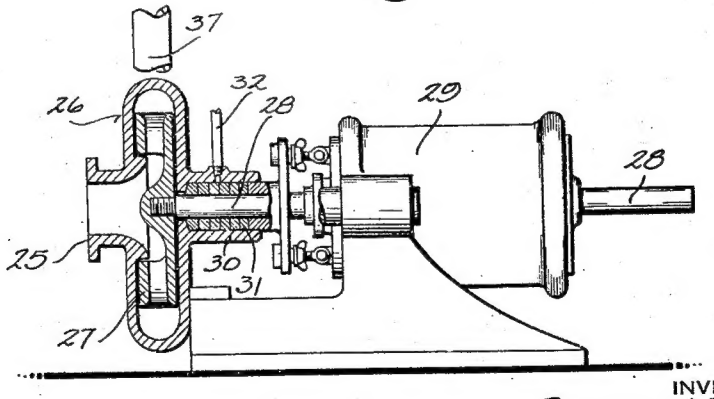

Fig. 5.

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POLISHING METHOD AND APPARATUS

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21 Claims. (Cl. 51—8)

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This invention relates to improvements in polishing methods and apparatus.

A primary object of the invention is to use fluid-borne abrasives to finish or polish surfaces and to be able to control the finishing and polishing operation with such accuracy as to be able to produce a highly finished surface on parts having the most minute tolerances.

Another object of the invention is to provide a new type of satin finish on metals, which has important advantages for bearings, and other purposes. In bearings the improved finish produced according to the method hereinafter to be disclosed holds an oil film in the bearing more satisfactorily than any other type of finish. Moreover, the finish has advantages quite apart from bearings in that it is very attractive and is rust resistant, and shows an increase amounting to as much as five to ten percent in tensile strength as compared with the same parts finished by other methods.

An important object of the invention lies in the fact that the wide control possible in its use permits of every type of operation from the coarsest rough or de-burring cut to the finest honing or polishing. As will hereinafter be more fully explained, the results achieved result from a novel method and apparatus using the abrasive in suspension in a liquid. I am able to deliver up to four to six times as much weight of abrasive material per minute as in any previous fluid-borne abrasive apparatus, at the same time controlling results so effectively as to be able to finish the most delicate parts.

Other objects will be apparent to those skilled in the art upon examination of the following disclosure of my invention.

In the drawings:

Figure 1 is a view of apparatus preferably employed in the practice of the invention, as it appears partially in front elevation and partially in transverse section, a dual installation being shown.

Figure 2 is a view taken in cross section through one of the treating devices shown in Figure 1.

Figure 3 is an enlarged detail of one type of nozzle.

Figure 4 is an enlarged detail view of another type of nozzle.

Figure 5 is an enlarged detail of a special circulating pump, worked out for use in connection with the invention.

Like parts are identified by the same reference characters throughout the several views.

Figures 1 and 2 show a preferred cabinet construction. Cabinets A and B may be assembled in any number of units for successive operations, this being advantageous because of the fact that my invention permits accurate control of the abrasive action from the coarsest to the finest work. Only one of the two units identically illustrated in Figure 1 will be described in detail.

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The treating chamber 7 encloses a sump at 8, having at 9 transversely extending supports, notched as indicated at 10 (Figure 1), to receive the bars 11 which support the work to be surfaced. By increasing or decreasing the number of bars and by varying their spacing, all types of work may be accommodated. If the work is irregular and has a projecting part, an opening may be left between some of the bars to accommodate such a part. The treating chamber 7 preferably has a front wall at 14 provided with a window at 15, and with an opening at 16 protected by a curtain 17 comprising suspended strips between which are introduced the hose to supply the nozzle 20, and between which the operator may insert his hands to manipulate the nozzle and the work, while observing the operation through the window 15.

The cabinet may also include, optionally, a chamber 21 within which the operator may stand, the doorway 22 being wholly or partially closed by a folding door or curtain 23.

An outlet pipe 24 leads from a point near but preferably slightly above the bottom of the sump 8 to the inlet 25 of a centrifugal pump 26. The pump, in its general organization, is of a type specifically designed to handle liquid containing foreign matter. The pump runner 27 is mounted directly on a shaft 28 journaled in bearings enclosed in housing 29. Thus the pump shaft has no bearings directly within the pump casing 26. The casing is, however, provided with a sleeve at 30 extending along the shaft and containing packing at 31. The design of the runner tends to maintain this packing under partial vacuum while the runner is in operation, but, as a further precaution against discharge of any of the abrasive carrying liquid along the shaft, I preferably employ at 32 a pipe controlled by an electromagnetic valve 33 communicating with a source 34 of water or other liquid under pressure. A time switch at 35 controls the valve 33 at stated intervals to inject water under pressure from the source 34 into the packing 31, thereby washing from the packing any abrasive which may have entered the packing from the pump casing.

While it is possible to maintain a constant low rate of flow through pipe 32 into the packing and

thence into the pump, even the lowest rate of flow, long continued, will unduly dilute the abrasive emulsion hereinafter to be described, and, if the flow is minute, stoppages result and control is difficult. By periodically opening the valve wide for short intervals I accomplish the necessary flushing with none of these disadvantages, and am able to control with accuracy the degree of dilution of the emulsion, and to compensate accordingly.

A measured amount of emulsion, hereinafter to be described, is introduced in the sump 8 at 36. Withdrawn from the sump by pump 26, the emulsion is delivered from the pump through pipe 37 into the supply tank 370, wherein the emulsion is maintained at 38 to a constant level by means of an overflow pipe 39 which drains the excess back to the sump.

From a point which is preferably well above the bottom of the supply tank 37, as represented by the T-fitting 40, the supply pipe 41 connects with hose 42 leading to the nozzle. The only other hose leading to the nozzle is the air hose 43 which connects with pipe 44, representing a supply of air under pressure, the connection being controlled by a valve 45. There may also be a valve 46 at the nozzle, for the operator's convenience.

The nozzle 20 is more particularly illustrated in Figure 3, and comprises a passage 47 for the emulsion, such passage leading to a changeable tip 48 with which the air jet tube 49 is aligned.

For other purposes of work the nozzle 20', as shown in Figure 4, may be used, the connections to it being the same but the renewable tip 50 being set at an oblique angle with reference to the supply hose. The air jet tube 51 is aligned with the fitting 50.

The abrasive comprises a liquid carrier having the abrasive material in suspension. In the past, liquids have been used as carriers for abrasive material, but in general the abrasives have been introduced into the carrier at the nozzle, and in no instance has the abrasive been in suspension in the carrier.

In the sand blasting art the finest abrasive capable of effective use in an air blast has been of the order of 80 mesh, and all attempts to use a liquid vehicle or carrier for abrasives have involved the use of the same sorts of abrasives generally used in pneumatic sand blasting apparatus. I have discovered that by using finer abrasives or by using emulsifying agents, or by both of these procedures, I am able to maintain the abrasive in suspension so that with the entire mass of emulsion in constant circulation I am able to assure a substantially uniform distribution of the abrasive throughout the liquid vehicle.

For the high degree of polishing, which is one of the outstanding achievements of the invention, the fineness of the abrasive exceeds anything previously thought usable in this art. As above pointed out, 80 mesh abrasive is the finest ordinarily used in sand blasting. The finest abrasives available on the market for use in lapping compounds and such other fine polishing work are about 650 to 700 mesh. This is the approximate fineness of talcum powder. The abrasives which I use in the practice of the present invention range all the way from 100 to 2500 mesh, the latter comprising an impalpable powder. The preferred range of sizes is from approximately 200 mesh to approximately 1300 mesh.

The liquid vehicle is preferably water with chemicals added. In the apparatus disclosed I may, for ordinary work, use 50 pounds of abrasive in a dry state to 50 pounds of the aqueous vehicle. To the water I preferably add a rust inhibiting chemical, such as the product commercially known as Metrolux, which contains trisodium phosphate, sodium chromate, and a form of lime which contains boron.

To the water I further add any suitable wetting agent such as the product commercially known as "Duponol," a product of E. I. Du Pont De Nemours & Co., Inc., of which only one teaspoon is used in a batch of the proportions indicated. The chemicals have the effect of emulsifying agents in that they assist in keeping the abrasive particles in suspension.

Where the tolerance limitations of the work require a finer abrasive action, the amount of abrasive may be reduced in proportion to the amount of water. For example, where the tolerance limitations are of $^1/_{1000}$ of an inch, I would prefer not only to use a fine mesh abrasive but to use only 30 pounds of abrasive to 70 pounds of water, to which the above specified amounts of chemicals would be added. The amount of emulsifying agent may be varied according to the coarseness of the abrasive grains, it being understood, however, that even the largest of the abrasive grains which I use in the range above specified is smaller than any abrasive grains previously used either in pneumatic or liquid sand blasting.

While any desired abrasive material may be employed, silica flour being an example, I have found it particularly desirable to use a natural disintegrated mineral found in Arkansas and known as Novaculite. This mineral contains minute quantities of boron sulphate, which is a rust inhibitor, and whether because of the boron sulphate or otherwise, astounding results have been had through the use of Novaculite flour in the emulsion of this invention. Parts exceeding in delicacy those found in the finest watch, have been polished with an emulsion including Novaculite, and, after repeated handling and exposure, have retained their polish over long periods of time without a sign of rust. The cabinet in which the Novaculite emulsion is used will show no sign of rust, whereas an adjoining cabinet containing an identical emulsion save for the substitution of silica flour for the natural Novaculite, will, upon being allowed to stand empty, show signs of rust.

Using the amounts of emulsion specified, I have employed at 26 a pump having a capacity of approximately ten gallons per minute. Such a pump will circulate the entire charge of emulsion through the apparatus with considerable rapidity. Using air at 90 pounds pressure at the rate of approximately 100 cubic feet per minute, the nozzles shown will discharge the emulsion against the work at such a rate as to treat the work with from 8 to 12 pounds of abrasive per minute. This compares with only about 2½ pounds of abrasive per minute, which is the maximum achievement in conventional sand blasting.

The finish produced by the use of these extremely fine abrasives in an aqueous emulsion, propelled, however, by air, is unique and wholly different in appearance from a finish which can be had by any other method. The surface becomes velvety smooth to the touch, and satinlike in appearance. Its effect is one of light diffusion, indicating that the surface, for all of its apparent smoothness, contains minute cells or peened sockets in which lubricant will be carried when the finished surface is used in a bearing.

The resulting finish has been found to be more satisfactory in the surfacing of bearings than any previously known.

It is very desirable to use air rather than water as a means of imparting energy to the jet delivered from the nozzle. If water were added the character of the emulsion would constantly be changing. It is important to the control of the character of the finish and the amount of metal to be removed that the proportion of water to abrasive in the emulsion be kept relatively constant. Moreover, the fact that I employ chemicals in the emulsion makes it desirable to avoid undue dilution. Since the only water added to the emulsion is that which flushes the packing of the pump, I am able to operate over long periods with a single charge of emulsion without materially changing the specified proportions of the ingredients. However, air would not be as satisfactory to impel the abrasive jet if the air had to do work in delivering the emulsion to the nozzle, as much of the force of the jet would then be lost. It will be noted that the circulation maintained by the pump is such that at all times a supply of emulsion is maintained in the overhead tank 37 at a constant pressure to flow by gravity to and from the nozzle whether or not the air valve is open. Thus, the only function of the air is to give force to the jet issuing from the nozzle.

The metal particles cut from the work by the abrasive will be deposited either in the sump 8 or in the portion of the overhead reservoir 370 below the outlet 40 therefrom. When the charge of emulsion is replaced, from time to time, these heavier particles may be removed. While they may be carried in suspension in the emulsion, to some extent, due to the constant circulation maintained by the pump, and due to the presence of the emulsifying agent, they will tend to settle out when the operation of the pump ceases, whereas the extremely fine particles of abrasive material tend to remain indefinitely in suspension.

While the invention has been described primarily from the standpoint of the apparatus and the physical characteristics of the emulsion, my improved method has also been disclosed and may be summarized as follows:

I prepare an aqueous emulsion in which an extremely fine abrasive is in suspension in predetermined ratio. I circulate the charge or emulsion upon a predetermined path in which the emulsion flows under pressure to a nozzle to which air is delivered to deliver the emulsion in the form of a pressure jet from the nozzle upon the work.

The reason for the substantially permanent inhibition of rust when the novaculite is used remains an unexplained phenomenon, but it is believed that there may be some electrical basis. In any event, there is an electrical discharge very clearly apparent at the nozzle when novaculite is used as the abrasive agent in the aqueous emulsion as above described, which does not manifest itself in the use of any other abrasive I have tried. The electrical discharge occurs throughout the water issuing from the nozzle and takes the form of a luminescent glow of a bluish or purplish color, resembling that which occurs in ultra violet apparatus at the initiation of operation.

While electrical discharges in the form of sparks may be observed when any dry sand blast abrasive is rubbed together in the dark, the novaculite is the only material known to me which causes such a glow in an aqueous carrier in which it is entrained. The entire stream of emulsion and abrasive from the nozzle tip to the impact zone is caused to glow in the use of my improved apparatus and the practice of the method herein described.

I claim:

1. In polishing apparatus of the type in which a polishing medium is forcibly projected into contact with work to be polished, the sub-combination which comprises as such polishing medium an aqueous emulsion containing novaculite as an abrasive in suspension.

2. Apparatus of the character described comprising the combination with a work support and a sump therebeneath, of a circulatory system connected with the sump and including an overhead chamber, a pump for maintaining circulation in said system including an overflow pipe returning from the chamber to the sump whereby to maintain a substantially constant head in the chamber, a feed pipe from the chamber, a nozzle with which said pipe communicates, and a batch in the sump for circulation through said system, said batch comprising a liquid vehicle and an abrasive, said nozzle having air supply connection thereto for jetting the liquid vehicle and abrasive from the nozzle.

3. The device of claim 2 in which the abrasive is in, and in substantially uniform distribution throughout suspension in the vehicle, the amount of vehicle being at least as great as to be substantially equal in weight to the abrasive therein.

4. The device of claim 2 in which the batch in the sump comprises an emulsifying agent and the abrasive is sufficiently fine to be maintained in suspension by such agent under the conditions of recirculation existing in such system.

5. A device of the character described comprising a sump, an elevated receptacle and circulatory connections therebetween including an overflow pipe from said receptacle to said sump, a supply pipe from said receptacle, a nozzle to which said supply pipe is connected, a pipe leading from the sump to the overhead receptacle and including a pump and a work support in the path of said nozzle and disposed over the sump.

6. The device of claim 5 in which the pump comprises a centrifugal pump including a casing, a runner, a shaft entering the casing and connected to the runner for the operation thereof, a sleeve about the shaft at the point where the shaft enters the casing, and means for introducing a flushing liquid through said sleeve about the shaft.

7. The device of claim 5 in which the pump comprises a centrifugal pump including a casing, a runner in the casing, a shaft entering the casing and connected to the runner for the actuation thereof, a sleeve through which the shaft enters the casing, the pipe communicating with the space between the shaft and sleeve and provided with a valve connecting it with a source of flushing liquid under pressure, and means for periodically opening said valve to admit flushing liquid about the shaft.

8. The device of claim 5 in which the pump is a centrifugal pump comprising a casing, a runner within the casing, a shaft entering the casing and connected with the runner for the operation thereof, bearings for the shaft externally of the casing, packing about the shaft where it enters the casing, and means for periodically admitting flushing liquid under pressure to said packing.

9. Apparatus of the character described comprising the combination with a centrifugal circulating pump including a casing, a runner, a shaft entering the casing and connected with the runner, and a sleeve surrounding the shaft adjacent the point where the shaft enters the casing, of a flushing pipe communicating with the space between the shaft and sleeve and provided with a valve controlled connection to a source of flushing liquid under pressure, and means for intermittently opening and closing such valve.

10. Apparatus of the character described comprising the combination with a centrifugal circulating pump including a casing, a runner, a shaft entering the casing and connected with the runner, and a sleeve surrounding the shaft adjacent the point where the shaft enters the casing, of a flushing pipe communicating with the space between the shaft and sleeve and provided with a valve controlled connection to a source of flushing liquid under pressure, and means for intermittently opening and closing such valve, said means comprising means whereby the valve is opened periodically at stated intervals and is promptly re-closed whereby small quantities of flushing liquid are introduced at regular intervals and under substantially full pressure.

11. The device of claim 9 in which said means comprises an electromagnetically operable valve normally closed and provided with electromagnetic means for opening it, together with a time switch for periodically energizing said electromagnetic means for predetermined intervals.

12. In apparatus of the character described, the combination with a nozzle having a passage for liquid, a discharge tip with which said passage communicates, and an air tube entering said passage and directed toward said tip and operatively connected to a supply of air under pressure, of means for delivering liquid and entrained abrasive particles to said nozzle independently of the air, whereby the entire energy of the air may be directed toward the jetting of the liquid and entrained abrasive particles from the tip, the said means for delivering the liquid and entrained abrasive particles to the nozzle comprising an overhead accumulating tank having an overflow and means for pumping liquid and entrained abrasive particles together to said tank for flow to the nozzle under a substantially constant head determined by the elevation of said tank and the overflow therefrom.

13. A method of finishing a bearing which comprises the polishing of the bearing surface by jetting a liquid-borne abrasive finer than 700 mesh against the bearing surface.

14. The method of finishing a bearing surface which comprises the jetting of a carrier liquid and entrained particles of abrasive of approximately 1200 mesh against such surface.

15. A method of cleaning and polishing which comprises the suspension of a predetermined amount of abrasive particles in a predetermined amount of carrier liquid, circulating the liquid suspension of abrasive particles upon a predetermined path while maintaining the portions of liquid and abrasive approximately constant and maintaining the distribution of the abrasive approximately constant throughout the carrier liquid, and jetting portions of the circulating carrier liquid and abrasive against the surface to be cleaned or polished.

16. A method of cleaning and polishing which comprises the jetting against the surface to be cleaned or polished of a liquid suspension of novaculite rock.

17. The method of claim 16 in which the novaculite rock is reduced to a fineness of less than 100 mesh.

18. The method of claim 16 in which the novaculite rock is first reduced to a fineness of at least approximately 700 mesh before being placed in suspension in the carrier liquid.

19. A method of cleaning and polishing which comprises the admixture of a powdered abrasive with an aqueous carrier liquid and an emulsifying agent, thereby suspending the powdered abrasive in the carrier liquid, the delivery of the liquid and suspended abrasive to an air jet and the jetting of the liquid and suspended abrasive against the surfaces to be cleaned or polished.

20. Polishing apparatus comprising an aqueous emulsion containing novaculite as an abrasive in suspension, in combination with means for circulating said aqueous emulsion in contact with work to be polished.

21. Polishing apparatus comprising a charge of liquid carrier and abrasive particles in suspension therein in approximately fixed proportions, a collecting sump, a work support above the sump from which portions of the treating charge will drain into the sump, a nozzle, an air supply connection to the nozzle, an emulsion supply for said nozzle including a circulatory system leading from and returning to said sump and intermediately in communication with the nozzle and means for pumping the said charge through the system to supply the nozzle with portions of the charge under pressure.

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